Semi-Annual Progress Report

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Task Objectives

The objectives of the last six months were:

Complete Algorithm Theoretical Basis Document for planned at-launch data products based on Review Panel comments

Continue to review plans for EOSDIS and assist ECS contractor

Complete development of local information management system

Complete initial analysis of sun-stimulated fluorescence data collected off northern California

Participate in SeaWiFS/MODIS primary productivity workshop

Participate in cruise in the Southern Ocean

Develop bio-optical mooring for deployment in 1995.

Work Accomplished

- Project Data and Information System Plans
  - Ad hoc Working Group on Production

In response to requests from Bruce Barkstrom (NASA/Langley), I provided information on my data needs and product delivery schedule for my MODIS products. This information was coordinated through Ed Masuoka of MODIS Science Data Support Team. This information included revised descriptions of product dependencies between my products and other MODIS products. This information was incorporated

into my revised Algorithm Theoretical Basis Document.

- Local Scientific Compute Facilities

  - Advanced Networking

The joint project with Otis Brown at the University of Miami was completed in early November. Under the auspices of the Naval Research Laboratory, MCI installed an ATM link between our sites and NRL in Washington, DC. Unfortunately, the network was only stable for three weeks before it was dismantled. We were able to transfer one years' worth of Pathfinder AVHRR imagery for use in our optimal interpolation routines. We have continued to improve the software on the Thinking Machines CM-5; presently one day of data takes one hour of compute time. We continue to explore options with Navy personnel to reinstall the network.

The NIIT project which links OSU with Berrien Moore at University of New Hampshire continues to be on hold. A proposal was made to HITC to support development of SCF to SCF links to test the software and hardware requirements for interdisciplinary research. We are completing negotiations with HITC on specific deliverables and schedules.

  - Information Systems Development

We have installed our Microsoft SQL Server data base, and we are now loading the data base and developing various clients. The client/server architecture is based on the following three major architectural requirements: (1) the system utilizes the embedded communication features of Microsoft's NT Advance Server and Windows 95, (2) our data will be stored in SQL Server (a relational database) running on an NT Server, and (3) the interface between the client applications and the server database will be via Microsoft's Open Database Connectivity (ODBC).

    i. Hardware Configuration

We purchased seven Dell personal computers to serve as clients for this information system. One machine was purchased as a system administration machine and one machine will be used for beta testing new operating systems from Microsoft. A dual-processor Hewlett-Packard LM server was selected to host the NT Advanced Server operating system and SQL Server. This machine was configured with 128 MB of error-correcting memory and 30 GB of disk. The total system price was about $30,000, far less than an equivalent UNIX server.

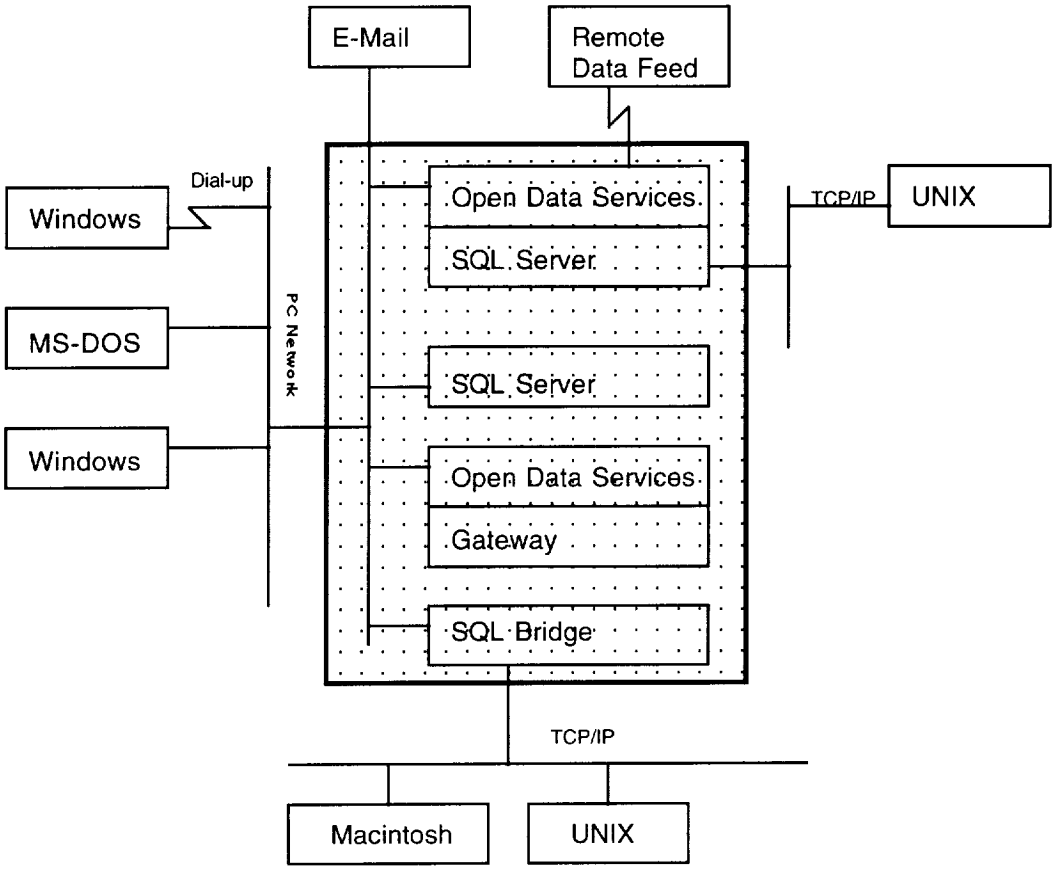
We are investigating low cost, high volume storage systems such as digital linear tape (DLT), optical media, and conventional hard disk drives. These costs have dropped dramatically in recent years. For example, a DLT system capable of storing 0.5 TB

now costs about $45,000. However, much of the software written for such systems is based on a network backup/restore approach as opposed to a conventional file system where the data can be accessed as though it were on standard disk drives. We expect to evaluate several systems in the next few months. If successful, we will acquire a system to expand storage capacity.

Lastly, we are shifting our existing magneto-optical juke boxes (30 GB and 100 GB) to the H-P LM server. These systems presently hold our archive of west coast temperature and ocean color imagery.

ii. SQL Server Relational Database

We are using Microsoft's SQL Server to act as a central hub through which enterprise data is transferred to the desktop. The basic configuration is shown below:



We have established links between SQL Server running under NT-AS and three clients: Windows NT, Macintosh, and UNIX. Because of conflicts in network protocols, access to SQL Server from the Macintosh client requires knowledge of the IP address; eventually advertising will work across the network, and the user will simply see a list

of possible SQL Server data bases that can be accessed. The Windows version will require Windows for Workgroups to be installed on the client; we are investigating the impacts of this change on our existing Novell Netware system as there are conflicts between these two network systems. UNIX connectivity is provided through a Sybase SQL Open Client running on a Sun 690. The Open Client software is bundled with SQL Server for Windows and Macintosh clients.

iii. Open Database Connectivity (ODBC)

Many commercial-off-the-shelf (COTS) applications now support ODBC as a means to connect easily to SQL data bases. We have established links between SQL Server and Excel running under Windows NT and Macintosh. SQL Server has been loaded with our bio-optical drifter data base. These drifters have been deployed in both the California Current and the Southern Ocean. Performance of these links is quite good. Data can be accessed directly from within the application of interest, allowing the user to use the application tools to manipulate the data without writing custom code or reformatting the data. We have been in contact with several analysis software vendors (e.g., MatLab, IDL) to encourage them to develop ODBC-compliant applications.

The next step in this process will be the use of Object Linking and Embedding (OLE) to develop custom applications that are closely integrated with SQL Server. Presently, we are testing plotting and analysis software from Axum, Inc. that is OLE 2.0 compliant. The package works well under Windows and we plan to extend its use in our system. The next version of SQL Server will support OLE 2.0, thus strengthening the links between the data base server and the applications.

We are building our UNIX client on top of Mosaic. As reported last time, our initial prototype used a custom socket server to provide the link between Mosaic and our UNIX-based Ingres data base. Unlike most Mosaic clients, this allowed the used to directly query our data base, rather than browse through a series of pre-selected data files. Our present Mosaic client now accesses our NT-AS SQL Server through the Sybase Open Client running on the Sun 690. We are evaluating the performance of this system. We plan to add some simple analysis capabilities as part of this interface.

- Future Directions

As discussed above, we will continue to enhance the functionality of the present system as new operating system features become available. The number of applications that support OLE and ODBC is increasing, and we will rely on this capability to link applications and the data management system.

We have begun discussions with Illustra about using their data base capabilities which include object-like functions as part of our information management system. This system was used successfully as part of the Sequoia 2000 project.

Our main focus will be loading our existing data into this system. We have included all of our drifter observations, and we are now beginning to load in our 15,000 color and SST images from the west coast. We are also acquiring more hydrographic and current observations along with moored bio-optical measurements.

- Data Analysis and Interpretation

  - Journal Publications

A manuscript describing the role of remote sensing in coastal oceanography has been reviewed and is in press as part of the Dahlem (Germany) conference book on coastal upwelling. Two manuscripts are in preparation. The first is an analysis of the fluorescence data collected from the bio-optical drifters. The second is analysis of the Lagrangian particle statistics calculated from the drifter positions and the bio-optical measurements.

  - Analysis of Ocean Drifter Data

All 24 bio-optical drifters have been deployed in the California Current as part of ONR's Eastern Boundary Current study. Five drifters continue to relay data back to shore, although their optical sensors have been fouled by biological growth. Results of the initial analyses were presented at the MODIS team meeting. Using the ratio of 683 nm radiance to 555 nm radiance, it was apparent that this ratio provided a clear indicator of when bio-fouling became critical. This transition was marked by a dramatic increase in the noise level of this ratio. The length of time before fouling appeared varies from 60 to 90 days, depending on the environmental conditions experienced by the drifter.

We concentrated our analysis on the period before fouling occurred. Using the radiance ratio algorithm developed by Dennis Clark for CZCS, we estimated chlorophyll concentrations according to the following:

$$\text{Chl } a = \mathrm{a} * \left[\frac{L_u(443) + L_u(510)}{L_u(555)} \right]^{\mathrm{b}}$$

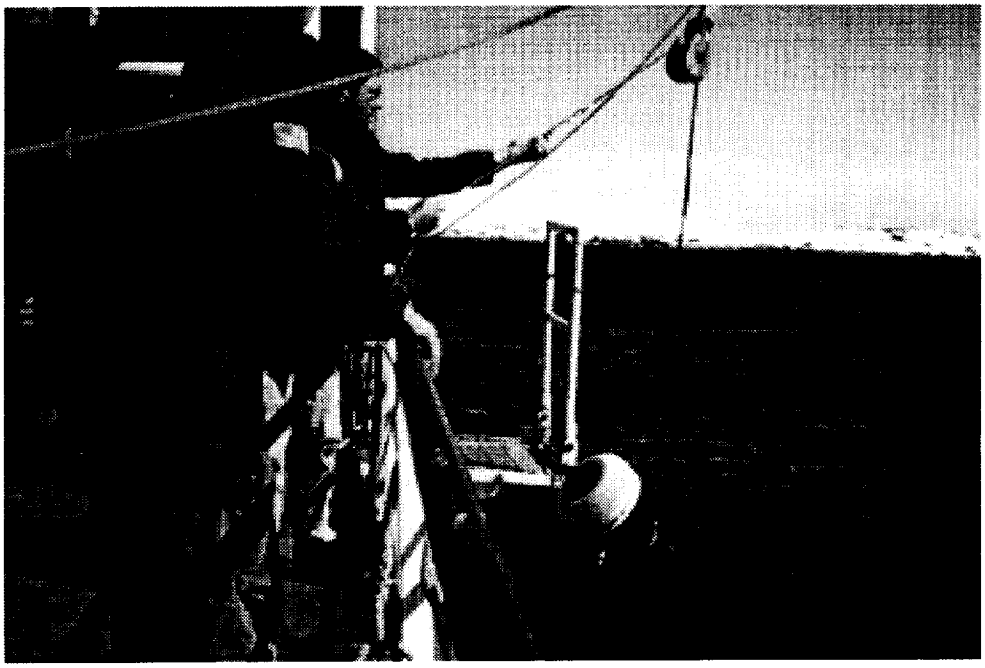
where $L_u(x)$ corresponds to the upwelled radiance at wavelength x. We used in situ measurements of chlorophyll collected by Tim Cowles to fit the two free parameters (*a* and *b*). The patterns of chlorophyll matched what we would have expected in an upwelling region with higher chlorophyll values associated with cold, nearshore waters. We calculated normalized chlorophyll fluorescence at 683 nm by the chlorophyll estimate. This ratio varies between 0.08 and 0.25, depending on the drifter. We are now examining these data for characteristic patterns of variability based on location and season.

In parallel with the analysis of fluorescence data, we are calculating Lagrangian particle statistics, in collaboration with Andrew Bennett. The first step has been the

elimination of outliers in the time series. We then spline fit the positions of the drifters and resample the time series at regular intervals. Covariance and cross-covariance functions are then calculated. These statistics will provide information about the near-surface circulation. We will next apply these techniques to the bio-optical results. These data will be analyzed in the context of earlier models of phytoplankton patchiness and Lagrangian statistics. Although this is primarily an oceanographic research topic, the resulting statistics will have relevance for developing composite data fields from MODIS data.

Ricardo Letelier participated in a 4-week cruise in the Southern Ocean last December. The experiment (known as SANTA CLAμS or Studies in ANTarcticA Coupled Linkages Among μ-organismS) was designed to study several aspects of the microbial ecosystem near the Antarctic Peninsula. Our study planned to characterize the sun-stimulated fluorescence signal of chlorophyll in the coastal waters. Upwelled radiance was measured at 412, 449, 490, 510, 670, and 683 nm using a Tethered Spectral Radiation Buoy (TSRB) from Satlantic, Inc. The TSRB also measured temperature and surface downwelling irradiance at 490 nm.

The cruise covered the region of the Hugo Archipelago, Crystal Sound, Paradise Bay, Gerlache Strait, Deception Island, and Drake passage. Surface chlorophyll concentrations ranged from 0.5 mg/m^3 to 15 mg/m^3. These values will be compared with estimates from the TSRB. Measurements were made of nutrient concentration, phytoplankton species composition and photosynthetic activity. These data will be used to study the variability of the fluorescence:productivity relationship.



Deployment of the TSRB off the Antarctic Peninsula

Two bio-optical drifters, identical to those in the California Current, were deployed

during the cruise. One was placed in a coastal environment (Gerlache Strait) and one in the open ocean (Drake Passage). The drifters are now relaying their data back via Argos and should trace the evolution of ocean color during the Antarctic summer.

We have nearly completed construction of our bio-optical mooring (paid for primarily by EOS interdisciplinary funds). The mooring consists of a Satlantic spectroradiometer, a small current meter, and data logger. The total mooring costs approximately $15,000. A test deployment is now planned for next month at the Hawaii Ocean Time Series station which is operated as part of JGOFS. The system will be recovered in May. If all tests are successful, then it will be redeployed in the Antarctic Circumpolar Current later this year. This will provide valuable in-water optical information, assuming that SeaWiFS is launch successfully this summer.

- Algorithm Theoretical Basis Document

I submitted my revised Algorithm Theoretical Basis Document (ATBD) in late October. Revisions were based on a few minor criticisms as well as clarifying some portions of the text that were confusing to the Review Panel. I also updated text on product dependencies based on discussions at the MODIS Team meeting in October.

As part of the next version of the ATBD, Dr. Letelier and I are conducting an error analysis. This study will be included in the ATBD, as well as a more complete description of the theory behind fluorescence and primary productivity. This latter section will be developed into a separate journal publication.

- SeaWiFS/MODIS Productivity Workshop

Dr. Letelier attended the Productivity workshop in October. This activity, led by Dr. Wayne Esaias, is evaluating several methods of estimating primary productivity using satellite data. Dr. Letelier presented some of his results on fluorescence. Although the initial focus of the workshop is on SeaWiFS, fluorescence data will eventually play a role in such algorithms as more sensors extend their capabilities to include fluorescence observations.

Anticipated Future Actions

Work will continue with the ECS contractor and the MODIS Science Data SUpport Team. A meeting of the MODIS Ocean team will take place in February to discuss specific issues related to code integration and delivery of beta code. The fluorescence line height algorithm is straightforward and will be easy to include in the Miami package. The most complex part will be quality assurance and flagging.

We have completed the first phase of our high speed network test. The results were disappointing because of the instability of the underlying ATM network assembled by

MCI. The actual science tests were only run for 4 weeks before the network was dismantled by MCI. We are exploring other avenues for re-establishing the network, particularly with Naval Oceanographic Office support. Our other network experiment with Berrien Moore to test SCF/SCF interactions has been delayed because of scheduling difficulties and the need to iron out details related to the HITC contract.

Our information management system using SQL Server and Windows Advanced Server is now running. We are developing client applications to merge our analysis tools with the data management system. We will continue to load satellite and drifter data into the base, as well as refine the client software. We will continue to track new technologies in the area of object data management as appropriate.

Dr. Letelier is collaborating with Dr. Dale Kiefer (University of Southern California) on chemostat experiments with natural fluorescence. Dr. Kiefer is an expert on fluorescence and phytoplankton physiology, and he is very interested in our field observations of sun-stimulated fluorescence. These data sets include our drifter observations as well as the long time series of measurements from the JGOFS HOTS site. We will build and operate a chemostat cultures of several types of phytoplankton. We will conduct experiments on the fluorescence response as a function of light history, nutrient conditions, and species. We are acquiring a Fast Repetition Rate (FRR) fluorometer as part of these studies. The FRR fluorometer was developed by Dr. Paul Falkowski (Brookhaven National Laboratory) as part of his studies of primary productivity.

We will participate in the Multisensor Ocean Color workshop planned for February in Miami. The goal of this workshop is to develop a plan to produce consistent, validated ocean color data products that will make us of the full suite of ocean color sensors. In the late 1990's, there will be several ocean color sensors in orbit. Each will have different sampling and measurement characteristics, and combining these data sets into a consistent time series suitable for analysis of long-term trends poses several significant challenges.

Finally, we are developing a proposal to the Office of Naval Research to study small-scale variability in nearshore environments. We are exploring low cost moorings to measure circulation and bio-optics in shallow water (less than 100 m). Our goal is to develop moorings that cost in the range of $2000 to $3000 so that small grids of 16 moorings could be used in short-term deployments. Because of the challenges of working in the nearshore environment (complex optical properties, intense small-scale variability, damage from fishing and recreational activities), such systems must be inexpensive in order to make measurements on the critical scales of variability.

Problems and Solutions

No significant problems have been encountered during this reporting period.